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TO WHOM IT MAY CONCERN:

Be it known that I Trevor Dean, citizen(s) of the UK, residing at South View, 2 Windmill Lane, Widmer End, High Wycombe, Buckinhamshire HP15 6AF, United Kingdom, has invented an improvement in

PAPER PLANT - METHOD AND APPARATUS FOR PRODUCING PULP FROM CELLULOSIC FIBROUS RAW MATERIALS AND RECOVERING CHEMICALS AND ENERGY FROM PULP LIQUORS

of which the following is a

SPECIFICATION

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application is a continuation of International Application No. PCT/GB02/03641, which was filed on August 7, 2002 and which claims priority from U.K. Application No. GB 0119237.6, which was filed on August 7, 2001.

BACKGROUND OF THE INVENTION

[0002] This Invention relates to a paper plant having a small-scale process by which cellulosic raw materials are converted into pulp for papermaking and black liquor effluent generated from the pulping process is treated to recover organic and inorganic chemicals and energy. It is also to be understood that while the combined process has been designed for a paper plant, the individual process steps and apparatus used may be used

individually in other suitable processes, not necessarily related to paper and pulp production.

[0003] Agricultural residues such as wheat and rice straw contain cellulose and can be a good raw material for papermaking. However, as these raw materials are bulky, transportation costs mean that they are best pulped locally and therefore on a relatively small scale of around 10-100 tonnes of pulp production per day.

[0004] Pulp mills generate black liquor effluent which if discharged to watercourses causes severe pollution. The technology currently used to treat black liquor effluent is, depending on local economic conditions, only economically viable on a scale of not less than 60,000 tonnes of pulp production per annum. The typical scale of a modem wood pulp mill is over 360,000 tonnes of pulp production per annum.

[0005] Lack of economically viable technology to deal with black liquor effluent under 60,000 tonnes per annum of production has meant that many existing small pulp mills have been forced to close to stop pollution of watercourses. This lack of suitable technology has also prevented the establishment of new small pulp mills, in particular new mills that might have used agricultural residues.

[0006] The subsequent lack of demand for small pulp mills has meant that little research and development of small pulp mill technology has been carried out. Consequently small pulp mill technology and straw pulping in particular has not advanced as far as large scale wood pulping technology during the latter part of the 20th century. Current small pulp mill technology is therefore relatively resource inefficient. Also there are particular properties of straw as a raw material, which can cause problems

in processing and in the quality of the finished pulp which have not been addressed by current technology. These include partially pulped nodes leading to imperfections in the finished paper and drainage problems on the paper machine caused by over processing of the straw fibers. In addition processes currently used to pulp straw leave silica, which is present in straw, in the black liquor which then forms glass like deposits when the effluent is concentrated for treatment, leading to inefficiencies and down time for cleaning.

[0007] The present invention seeks to reduce or obviate one or more of these problems.

[0008] According to a first aspect of the invention, there is provided a treatment apparatus for treating fibrous cellulosic raw material suitable for use in a paper making plant comprising extracting means for extracting contrary material from the raw material, crushing means for crushing the raw material to remove nodes therefrom and splitting means for splitting the crushed raw material lengthways.

[0009] The extracting means may comprise a conveyor belt provided with means for enabling the removal of contrary material.

[0010] The crushing means may comprise a pair of counter rotating knurled rollers between which the raw material passes.

[0011] The splitting means may comprise a pair of counter-rotating pinned rollers and between which the crushed material passes.

[0012] Between the crushing means and the splitting means may be provided means for further removing contrary material present in the crushed material.

[0013] According to a second aspect of the invention, there is provided a method for treating fibrous cellulosic raw material suitable for use in a paper making plant comprising extracting contrary material from the raw material, crushing the raw material from which contrary material has been removed to remove nodes therefrom and splitting the crushed raw material lengthways.

[0014] The extraction of contrary material may take place on a conveyor belt provided with means for enabling the removal of contrary material.

[0015] The crushing of the raw material may take place between a pair of counter rotating knurled rollers between which the raw material passes.

[0016] The splitting of the crushed material may take place between a pair of counter rotating pinned rollers and between which the crushed material passes.

[0017] Between the steps of crushing the raw material and splitting the crushed material, further removal of contrary material present in the crushed material may be carried out.

[0018] According to a third aspect of the invention, there is provided an apparatus for pulping fibrous cellulosic raw material comprising a co-rotating twin screw conveyor, that is the screws both turn in the same direction, the conveyor being divided up into a plurality of zones, means for inserting treatment materials such as chemicals to assist in the pulping process such as sodium hydroxide into at least one zone and means for controlling the temperature and/or pressure in at least one of the zones.

[0019] The conveyor may comprise at least three zones comprising a feed zone, a treatment zone to which treatment material is added and a pressure zone maintained at a pressure above atmospheric.

[0020] The conveyor may comprise five zones comprising a feed zone, a treatment zone to which treatment material is added, a first pressure zone at a pressure greater than atmospheric to which treatment material is added, a second pressure zone at a pressure higher than the first pressure zone and a third pressure zone at a lower pressure than the second pressure zone.

[0021] The feed zone may be enlarged compared to the other zones to allow the raw material to be fed freely thereinto to increase the throughput of the conveyer. As the raw material moves forward into the treatment zone and the first and second pressure zone, the area within the co-rotating twin screw conveyor may be continually decreased which has the effect of continually increasing the pressure within the zones.

[0022] The pressure and temperature of the first and third pressure zones may be the same.

[0023] Steam may be inserted into the treatment zone and pulping agents may be inserted into the first pressure zone.

[0024] The feed zone and the treatment zone may be maintained at atmospheric pressure.

[0025] The raw material may be passed through five zones comprising a feed zone, a treatment zone to which treatment material is added, a first pressure zone at a pressure

greater than atmospheric to which treatment material is added, a second pressure zone at a pressure higher than the first pressure zone and a third pressure zone at a lower pressure than the second pressure zone.

[0026] The addition of heat, steam or any other treatment materials may take place at any point along the co-rotating twin screw conveyor.

[0027] Extraction of any liquids or volatiles may take place at any point along the co-rotating twin screw conveyor.

[0028] Pressure can be increased or decreased at any point within the co-rotating twin screw conveyor.

[0029] According to a fourth aspect of the invention, there is provided a method of pulping pre-treated or untreated raw material comprising passing the raw material through a plurality of zones, inserting treatment material into at least one zone and controlling the temperature and/or pressure of at least one of the zones.

[0030] The raw material may be passed through at least three zones comprising a feed zone, a treatment zone to which treatment material is added and a pressure zone maintained at a pressure above atmospheric.

[0031] The raw material may be passed through five zones comprising a feed zone, a treatment zone to which treatment material is added, a first pressure zone at a pressure greater than atmospheric to which treatment material is added, a second pressure zone at a pressure higher than the first pressure zone and a third pressure zone at a lower pressure than the second pressure zone.

[0032] The method may comprise controlling the pressure and temperature of the first and third pressure zones to be the same.

[0033] The method may comprise inserting steam into the treatment zone and inserting pulping agents into the first pressure zone.

[0034] The method may comprise maintaining the feed zone and the treatment zone at atmospheric pressure.

[0035] The method may comprise the addition of heat, steam or any other treatment materials at any point along the co-rotating twin screw conveyor.

[0036] The method may comprise extraction of any liquids or volatiles at any point along the co-rotating twin screw conveyor.

[0037] The method may comprise an increase or decrease of pressure at any point within the co-rotating twin screw conveyor.

[0038] According to a fifth aspect of the invention, there is provided an apparatus for treatment of black liquor effluent produced in a paper pulp manufacturing plant comprising, a processing vessel for treating the liquor at a concentration of 10 to 70 percent solids at a temperature between 300°C and 650°C, and a closed conveyor for transporting the concentrated liquor from the evaporator to the processing vessel.

[0039] The apparatus may comprise an evaporator for concentrating the liquor to 30-70% solids.

[0040] The apparatus may further comprise a tank for dissolving the product produced in the reaction vessel, a means of filtering the non-dissolved solids from the dissolved reaction product, a dryer to dry the undissolved reaction product and a boiler to recover energy from hot gases.

[0041] The solids content of the black liquor effluent arising from the co-rotating twin screw conveyor may be over 30% and so may mean that an evaporator is not required as part of the apparatus if used in conjunction with pulping from the co-rotating twin screw conveyor.

[0042] If required the processing vessel may also treat black liquor at 10-30% solids.

[0043] The processing vessel may comprise the chamber of a toroidal fluidized bed into which the concentrated black liquor is sprayed, the fluidized bed containing an earth oxide at a ratio of between 0.2:1 and 1.3:1 earth oxide to black liquor effluent dry solids, operating at stoichiometric or sub-stoichiometric conditions.

[0044] The closed conveyor may be a twin screw conveyor with an earth oxide, the ratio of earth oxide to black liquor being between 0.2:1 and 1.3:1 earth oxide to black liquor effluent dry solids so that it becomes a granular friable material.

[0045] The apparatus may include means for chemically converting the material in the fluidized bed into sodium hydroxide and/or sodium carbonate and a gas and liquids with a combustible component, which can be utilized for energy production.

[0046] According to a sixth aspect of the invention, there is provided a method of treatment of black liquor produced in a paper manufacturing plant comprising, passing

the liquor at a concentration of 10-70% solids to a processing vessel and treating the concentrated liquor therein at a temperature of between 300-650°C.

[0047] The method may comprise concentrating the liquor to 30-70% solids before passing it to the processing vessel.

[0048] The concentrated black liquor may be sprayed into the chamber of a toroidal fluidized bed containing an earth oxide at a ratio of between 0.2:1 and 1.3:1 earth oxide to black liquor effluent dry solids and set up under stoichiometric conditions or sub-stoichiometric conditions.

[0049] The concentrated black liquor may be fed into a twin screw conveyor with an earth oxide, the ratio of earth oxide to black liquor being between 0.2:1 and 1.3:1 earth oxide to black liquor effluent dry solids so that it becomes a granular friable material.

[0050] The output of the twin screw conveyor may be fed to a toroidal fluidized bed reactor operating under stoichiometric conditions or sub-stoichiometric conditions.

[0051] The method may include means for chemically converting the material in the fluidized bed into sodium hydroxide and/or sodium carbonate and a gas and liquids with a combustible component that may be utilized for energy production.

DESCRIPTION OF THE DRAWINGS

[0052] The invention will now be described in greater detail, by way of example, with reference to the drawings in which:

[0053] Figure 1 is a block diagram of the entire process

[0054] Figure 2 is a schematic view of a roller arrangement for use in the raw material pre-treatment process

[0055] Figure 3 is a schematic view of the construction of a self cleaning pin roller which may be used in the roller arrangement of figure 2;

[0056] Figure 4 is a schematic view of a possible embodiment of the co-rotating twin screw conveyor and

[0057] Figure 5 is a block diagram of a preferred embodiment of the black liquor effluent treatment apparatus.

[0058] Wheat straw is usually chopped before pulping. Wheat straw contains nodes within the stem which usually remain intact if straw is chopped before pulping. This is a serious drawback in the production of quality paper pulp with the resulting poor quality paper being produced.

[0059] In accordance with the invention, a new method is employed which crushes the nodes, opens out the straw stem lengthways in a gentle fashion and feeds the raw material into the pulper in a positive, metered and continuous process.

[0060] The entire process will now be described in general terms in relation to figure 1:-

[0061] Firstly the material to be treated is fed to a conveyor belt 9 which has included in it means for the extraction of contrary material from the raw material. The conveyor feeds the resulting raw material to a series of pairs of rollers 10. A first pair crushes the

raw material to remove nodes and a second pair splits the raw material lengthwise. A third pair, between the first and second pairs, removes any contrary material produced in the crushing operation.

[0062] Next, the pre treated raw material is fed to a co-rotating twin screw conveyor 12 which is divided into five zones comprising a feed zone, a treatment zone to which treatment material is added, a first pressure zone at a pressure greater than atmospheric to which further treatment material is added, a second pressure zone at a pressure higher than the first pressure zone and a third pressure zone at a lower pressure than the second pressure zone.

[0063] The pulped material output from this conveyor may then be further treated in dependence on the quality of paper to be produced.

[0064] Black liquor produced by the paper manufacturing plant is treated in a treatment plant 14 comprising an evaporator for concentrating the liquor to 30-70% solids, or used directly from the co-rotating twin screw conveyor if already of this concentration and passed by a closed conveyor at a temperature above 90°C to a processing vessel where it processed at a temperature between 300 and 650°C.

[0065] The processing vessel is a toroidal fluidized bed reactor into which the concentrated black liquor is sprayed, the fluidized bed containing an earth oxide at a ratio of between 0.2:1 and 1.3:1 earth oxide to black liquor effluent dry solids. This process converts the material into sodium hydroxide and/or sodium carbonate and a gas and liquids with a combustible component which can be used for energy production. The energy component may be recovered using a standard boiler.

[0066] The individual parts of the process will now be described:-

[0067] Referring now to Figure 2, after the bales of straw have been opened, straw is passed along a conveyor belt 101 where heavy items such as stones and other contraries such as plastic string are removed. The straw is then passed in to a feed hopper 103 which feeds the straw into to an arrangement of knurled rollers 105 and 107 which crush the nodes in the straw stem and rollers with pins which open the straw stem out lengthways in a gentle fashion. Thus straw is fed between first and second counter-rotating knurled crushing rollers 105 and 107 to crush the straw nodes. The crushed material then passes through two counter-rotating intermediate rollers 109 and 111 which prevent any contrary materials from damaging the rollers below.

[0068] The straw then passes through two more rollers 113 and 115, this time rotating in the same direction. These latter rollers are provided with pins which open and shred the straw lengthways and act in co-operation with a feed shoe.

[0069] The action of this system leaves the straw as shortened and opened out/shredded material without nodes. This will facilitate quicker chemical and steam penetration and so faster and more uniform pulping, whilst treating the fibers gently so preserving their length. This results in the production of an improved quality of pulp including a very significant reduction in visible "shiners" in the paper sheet, due to dispersion of parenchyma cells, improved drainage, a higher tensile and tear strength, a higher pulp yield and a reduced demand for pulping chemicals.

[0070] The treated straw then drops from the pinned rollers 113 and 115 into a feed hopper 117 leading to either a conveyor or blower system (not shown) which feeds the

treated straw into a live bottom bin for buffer storage of the prepared material prior to pulping.

[0071] The above discussed pinned and knurled or fluted roller opening and feeding system is specifically designed for straw but, with minor modifications, could be used for any other suitable raw materials including flax, hemp, bagasse and wood.

[0072] The pinned rollers can also be constructed to be self-cleaning when used with longer fiberd cellulosic raw materials such as hemp and flax. This is to prevent the material wrapping around the rollers and fouling the apparatus. A schematic of the functioning part of a pin roller is shown in Figure 3.

[0073] The pin roller 20 has an outer surface having a large number of radially extending pins 22. This is used with a matching perforated or woven belt 24 on which the material 26 being treated is carried. The pins 22 pick up the material 26 and as the belt 24 leaves the pins, it takes off the material keeping the pin roller 20 free from tangled fibers.

[0074] The above described process has been tested and developed with straw, flax and hemp through pilot scale laboratory trials.

[0075] The raw material from the buffer storage is thereafter pulped. To this end the raw material (straw, flax, hemp, bagasse, wood chips or any other cellulosic raw material) is drawn into a specially designed co-rotating twin screw extrusion unit 31 figure 4. In this unit the screw profiles are specially designed. The two outer sections 33 and 34 have flights going in a first direction while in the middle section 35 the flight

direction is reversed. The screw flights are manufactured from hardened steel with a deep cut flight and are specially designed to minimize fiber damage. This particular design results in a reduced energy demand, which means that a smaller drive shaft and gearbox can be used, which also reduces capital cost. The design of the screw profile and the reduced drive shaft size also allows throughput of raw material to be increased by an anticipated 400% over conventional co-rotating twin screws.

[0076] As can be seen schematically in figure 4, one embodiment of the conveyor has a first zone 37 to which the raw material is fed through a feed hopper 39 and a second zone 41 to which cooking liquor can be added through an inlet 43 and steam can be added to the conveyor jacket at 45. A third zone 47 is constituted by the reversed flight region 35 in which some liquor is squeezed out through a perforated wall 49. A fourth zone 51 is constituted by the remainder of the conveyer, namely the part 34 from which the pulp emerges through an output 53. It will be appreciated that while the screw conveyor shown is set up with four zones, any number of zones, suitably from 3 upwards can be used and for whatever treatment set up is required.

[0077] The unit is suitably of modular construction which facilitates making changes to both screw and barrel configurations. This could be a very cost-effective way to make use of one standard twin screw unit to process many different types of cellulosic raw materials and/or to produce different grades of pulp simply by changing the screw and barrel configurations. Machine speeds of between 50-500 rpm could be used. A speed of 50-250 rpm has been used in practice. The speed needs to be adjusted for the raw material used and the pulp quality required.

[0078] The twin screw can be built in such a way that chemicals and liquids can be injected and liquids or steam can be vented or removed in each zone. This is a standard feature of twin screw extruders.

[0079] It has further been discovered that a sophisticated gearbox and drive of the type conventionally used in twin screw extruders is not necessary to suitably pulp fibers. A simple gearbox and drive can be used, reducing the capital cost and energy consumption. It is anticipated that the pulping system will consume less than half the energy of a conventional twin screw used for this purpose.

[0080] One method of pulping cellulosic raw materials such as straw using the new system is as follows. Using a co-rotating twin screw with a barrel size of 100 millimeters, the co-rotating intermeshing twin screw extruder is set up with five zones as described below.

Zone	1	2	3	4	5
Action of zone	Feed zone	Steam zone Introduce steam	Pressure zone Introduce NaOH + other pulping agents	Pressure zone	Pressure zone
Temp °C	65	100	130	150	130
Pressure (bar)	0	0	2-3	4-5	2-3

[0081] Cellulosic raw material such as straw is positively fed into Zone 1 using an Auger.

[0082] Zone 1 is designed to be as open as possible in order to accept the material into the unit. The temperature is 65°C in Zone 1.

[0083] In Zone 2 saturated steam is introduced to prepare the material for pulping. Temperature increases to 100°C

[0084] In Zone 3 temperature and pressure are raised to 130°C, 2-3 bar pressure. Sodium hydroxide is added at a rate of 12-14% to dry raw material using a 15% solution. Other materials may be added here as will be referred to hereafter.

[0085] In Zone 4 temperature and pressure are increased m 150°C and 4-5 bar pressure.

[0086] In Zone 5 temperature and pressure are reduced to 130 °C and 2-3 bar pressure in preparation for the material leaving the twin screw system. The material travels through the twin screw unit in between 2-3 minutes. The screw speed is around 200 rpm.

[0087] In another embodiment of conveyor (not shown) one form of the conveyor, the feed zone is enlarged compared to the other zones to allow the raw material to be fed freely thereinto to increase the throughput of the conveyer. As the raw material moves forward into the treatment zone and the first and second pressure zone, the area within the co-rotating twin screw conveyor may be continually decreased which has the effect of continually increasing the pressure within the zones.

[0088] The pulp exiting from the twin screw would have approximately 50% moisture content and would be expected to have a Kappa Number of 50. This is a semi-chemical pulp suitable for use in fluted packaging for example. This result is a function of the rpm and the flight design or time spent in the twin screw extruder together with the pressure, temperature and amount of pulping chemicals used.

[0089] To go on and produce a full chemical pulp it will then be necessary for the pulp to be further digested in a single screw pulper using steam at 1-2 bar pressure (120°C) for a further 20-40 minutes. A Kappa Number of 14-20 is achieved after this further processing. The pulp is then ready to be bleached using conventional methods.

[0090] The Invention also provides a method of precipitating silica present in straw onto cellulosic fibers when pulping straw to make paper and so prevent it entering the black liquor effluent and causing scaling of evaporators or chemical recovery system.

[0091] Calcium hydroxide can be added in Zone 3 of the twit screw extruder at a rate of 4% to dry raw material (straw) with 8% sodium hydroxide when pulping straw as described previously. This method could be used in any alkaline based pulping system. This has the effect of precipitating sodium silicate onto the cellulosic fibers as calcium silicate. This prevents silica from entering the black liquor effluent and causing scaling of the evaporators or chemical recovery system.

[0092] The above system, in common with all traditional chemical pulping methods, produces an effluent liquor, usually called black liquor which must be treated if environmental and health hazards are to be avoided. Typically the black liquor is evaporated and conveyed to a separate processing stage for recovery of the digestion chemicals and energy content. The most common process for the treatment of the black liquor is high temperature combustion in an apparatus known as a Tomlinson recovery boiler. The disadvantages of the Tomlinson process include the requirement to use large and complicated furnaces making them uneconomic at small throughputs (<60000 tpa), the corrosive nature of the recovered smelt product and the risk of explosions between the

smelt and water. To date there are no economically viable small-scale black liquor effluent treatment processes available.

[0093] The present invention provides a treatment process to recover organic and inorganic chemicals and energy from black liquor effluent arising from the pulping of cellulosic raw materials to make paper. It is specifically intended to be used with the above-described pulping process but could be used alone to treat black liquor from other pulping processes. It is designed to be economically viable at small throughputs.

[0094] Referring to figure 5, a preferred embodiment of the effluent treatment process will now be described.

[0095] Black liquor effluent arising from the pulping process is collected in a digestion liquor storage tank 301 and concentrated to 30-70% solids using a standard evaporator 302 designed for concentration purposes. If the black liquor effluent comes from the co-rotating twin screw conveyor at a solids concentration of 30% or above it may be treated directly in the processing vessel eliminating the evaporation step. The concentrated black liquor is moved to a reactor vessel 304 at a temperature in excess of 90°C using an enclosed twin screw transport system 303. The enclosed transport system is used to minimize the loss of organic components through vaporization. A temperature in excess of 90°C is required to decrease the viscosity of the black liquor so that it will transport without resistance. The black liquor is treated in the reactor vessel 304 in either of two methods.

[0096] In a first method, the black liquor is introduced into a toroidal fluidized bed reactor 304 by spraying the concentrated liquor into the chamber of the reactor in which a

bed of fluidized material is supported. The material may be an earth oxide such as lime at a ratio of 0.3:1 of lime to black liquor dry solids. The mean particle size of the earth oxide may be between 1 and 4 mm. The reactor may operate under stoichiometric or sub-stoichiometric conditions.

[0097] In a second method, black liquor effluent is pre-mixed in the twin screw conveyor 303 with an earth oxide such as lime (CaO) in the ratio 0.3:1 lime to black liquor dry solids to become a granular friable material. The granular friable material is then screw fed into a toroidal fluidized bed reactor 304. The reactor may operate under stoichiometric or sub-stoichiometric conditions.

[0098] In a variation of both methods, the ratio of earth oxide, e.g. lime to black liquor dry solids may be in the range 0.2 to 1.3:1 lime to black liquor dry solids. The earth oxide may be supplied by a standard calciner 306.

[0099] In both cases the chamber of the toroidal fluidized bed reactor 304 is maintained within the temperature range 300 to 650°C where the necessary chemical reaction takes place in the space of seconds.

[00100] In a further possible embodiment of the process a portion of the solids within the toroidal fluidized bed reactor 304 may be recycled via the screw feeder 303 back to the reactor 304.

[0100] The material is converted by a chemical reaction to;

[0101] 1. Sodium hydroxide and sodium carbonate and lime within the fluidized bed reactor 304. The bed will overflow through a central discharge point and is then

dissolved in a dissolving tank 305 to recover sodium hydroxide as green liquor in the traditional manner known as re-causticisation. The green liquor is then filtered using a standard filter 306 to make a calcium carbonate sludge and white liquor (containing sodium hydroxide) for re-use in the pulping process.

[0102] However, in a variation of the process, if the temperature is carefully controlled, re-causticisation can take place in the reactor. In this case, sodium carbonate is not formed and the sodium hydroxide can be recovered without the use of the dissolving tank (306).

[0103] 2. A gas and liquids with a combustible component which can be utilized for energy production. The gas is collected to power a boiler 309 that will produce energy and steam for use in the pulp mill process line. In a further possible embodiment of the process the gas containing combustible components may be recycled to the fluidized bed reactor to provide heat for the chemical recovery reaction.

[0104] The calcium carbonate sludge may be dried to remove some water and sent to a second calciner reactor 308, which may be a toroidal fluidized bed reactor. This reactor may operate at a temperature of around 1100°C where calcium carbonate $CaCO_3$ is converted back to calcium oxide CaO for re-use in the black liquor effluent chemical recovery process.

[0105] Approximately 10% of the fluidized bed material generated may need to be removed from the process continuously in order to prevent the build up of heavy metals and other materials in the process.

[0106] If required, black liquor effluent below 30% solids can also be processed using this method (and has been tested). However energy consumption is greater and so this is not the preferred method.

[0107] It will be appreciated that individual elements of the above described process can be replaced by suitable equivalents without departing from the scope of the invention. Also any of the individual processes and apparatus may be used individually in other processes where they are suitable, not necessarily related to paper making.